Cyborg Beast
Instruction Manual

For further assistance, please contact e-NABLE
or The Creighton University Research Group

e-Nable: Resources: http://enablingthefuture.org/resources/
Facebook Page: https://www.facebook.com/#!/enableorganization
Google+ Community: http://bitly.com/e-nable
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Acknowledgements:

Thank you to all members of the e-NABLE group, The Creighton University Group, and Robohand. This updated version includes modifications from Ivan Owen, Peter Binkley, Marc Petrykowski, Adam Carson, and Jorge Zuniga. Special thanks to our beta testers and makers, Gregg Dennison, Frankie Flood, and Paul & Leon McCarthy.

Important Disclaimer

By accepting any design, plan, component or assembly related to the so called "e-NABLE Hand", including the "Cyborg Beast" design covered by this document, the reader understands and agrees that any such information or material furnished by any individual associated with the design team is furnished as is, without representation or warranties of any kind, express or implied, and is intended to be a gift for the sole purpose of evaluating various design iterations, ideas and modifications. The reader further understands that such improvements are intended to benefit individuals having specific disabilities and are not intended, and shall not be used, for commercial use. The reader understands and agrees that any individual associated with the e-NABLE organization shall not be liable for any injuries or damages resulting from the use of any of the materials related to the e-NABLE Hand. The reader further agrees to read and abide by the safety guidelines contained in the "General Recommendations for e-NABLE Prosthetic Devices" section of this document.

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Description

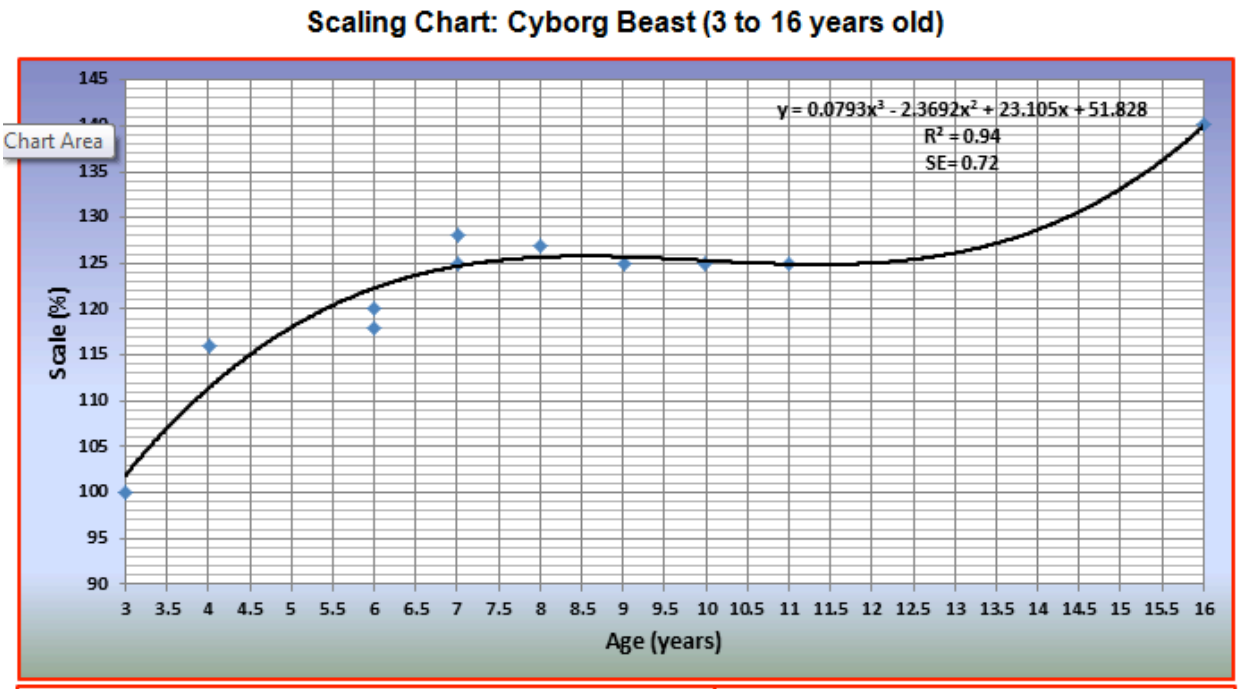
The Cyborg Beast is a remix of the snap together Robohand and the original Robohand . Most voluntary closing devices, including this design, need sufficient wrist movement and strength for proper function. This design doesn't require Orthoplastic. The fingers are designed for better griping and to avoid over extension of the proximal phalange and distal finger segment. The parts are designed to accept 1 to 2 mm cabling and elastic bands. This design should be compatible with any slicing software and 3D printer capable of accepting STL files, but testing has been primarily focused on Makerbot Makerware and Makerbot Replicator printers. This design was developed using ***Blender 2.7.***

Sizing/Scaling Instructions

Scaling Option 1: Scaling Chart (3 to 16 years of age)

Instructions: locate the child's age in the bottom (X axis) and follow the line to the regression curve and then locate the intercepting line corresponding to the scale % on the left side (Y axis). Example: For a child 5 years of age the scale % of the Cyborg Beast would be 118% (±1.44%).

Notes: This cubic regression equation was derived from a mixed sample of 11 children with ages ranging from 3 to 16 years of age. We hope to improve this algorithm as our research team recruits more subjects. Feel free to provide feedback about this chart. For more information contact Jorge M. Zuniga Ph.D. JorgeZuniga@creighton.edu



Instructions: locate the child's age in the bottom (X axis) and follow the line to the regression curve and then locate the intercepting line corresponding to the scale % on the left side (Y axis).
Example: For a child 5 years of age the scale % of the Cyborg Beast would be 118% (±1.44%).
Notes: This cubic regression equation was derived from a mixed sample of 11 children with ages ranging from 3 to 16 years of age. We hope to improve this algorithm as our research team recruits more subjects. Feel free to tell us if this chart works. For more information contact Jorge M. Zuniga Ph.D.
JorgeZuniga@creighton.edu

Age (yrs) = Scale % (from y = 0.0793x³ - 2.3692x² + 23.105x + 51.828)			
3 = 102	6.5=124	10=126	13.5=127
3.5= 107	7=125	10.5=126	14=129
4=111	7.5=125	11=126	14.5=130
4.5=115	8=126	11.5=126	15=133
5=118	8.5=126	12=126	15.5=136
5.5=120	9=126	12.5=126	16=140
6= 122	9.5=126	13=126	

Scaling Option 2: Measuring the User's Hand

To get a perfect fit, you will be scaling all the parts of the hand by a percentage, based upon the size of the user's hand.

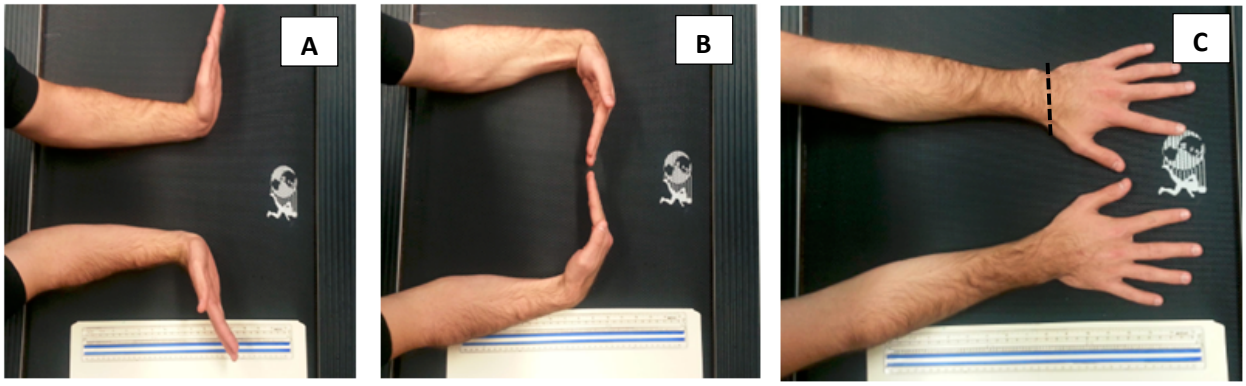
- Measure the knuckle area of the non-affected hand in centimeters or inches. If you measured inches, multiply your number by 2.54 to obtained centimeters.
- Convert centimeters to millimeters by multiplying your number times 10.
- Add 5mm to your measurement to account for the thickness of the Velcro based gauntlet.
    - For example: if the individual's hand measures 3 inches, then you will take 3 x 2.54 = 7.62 cm, then multiply this number times 10, so you will get 76.2 mm, add 5mm for the Velcro based gauntlet and you will get a total length of 81.2 mm.
- The corresponding knuckle area within the files you downloaded is 55 mm. Divide your result by 55. (Example: 81.2/55 = 1.48 rounded)
- Multiply the answer times 100 to get a percentage.
    - For example: 1.48 x100 = 148%
- Scale all the parts of the Cyborg Beast by this percentage before printing. This can be done using the 'Scale' tool in Makerware.
- Print all the components at the same scale.

Note: *We found that for sizes less than 118% of the original the holes size may compromise the structure of the Cyborg Beast. We are in the process of developing plastic pins to replace the Chicago Screws in the finger joints.*

Scaling Option 3: Working with an e-NABLE Volunteer at a Distance

If you need a device made at a distance, take three pictures of your hands and provide them to the e-NABLE community, according to these instructions.

Template for pictures for range of motion and sizing assessment



1. All pictures should include the entire forearm up to the elbow.
2. All pictures should be taken from directly above the arms and not at any angle.
3. Place a ruler that measures either inches or centimeters (or both) somewhere in the picture so that lines on the ruler are visible.
4. Bend the wrists as far as possible for picture A and B.
5. Draw a line in pen on the top of the wrist of the affected hand for picture C.
6. Complete the information gathering form for e-NABLE at http://goo.gl/lW1uX6
7. Email your photos to e-NABLE's Matching Team (enablematcher@gmail.com) to find an e-NABLE volunteer who can help determine the needed measurements and construct the device at no cost.

Printing Instructions

Best quality is obtained using ABS plastic with rafts and supports. The proximal phalanges and finger STL files contain one element. Please add or duplicate as needed on the build platform. The thumb phalange and distal finger segment are slightly different that the rest of the fingers. You can replace the thumb parts with the regular finger parts if you need to increase the length of the thumb.

For additional printing related tips, please visit: **http://enablingthefuture.org/resources/tips-for-successful-prints/**

Device Assembly

Assembly Materials

For assembly, you will need:

- Chicago screws (www.chicagoscrews.com).
  - Aluminum Chicago Screws – 3'' to 3 1/4"(or larger) for the knuckle. Size will depend on the width of the hand. You need 1 per hand.
  - Stainless Steel Chicago Screws - 3/16" Blind or 1/4" for Velcro based gauntlets (hand and forearm). The specific size would depend of thickness of the Velcro. You need 6 of these.
  - Stainless Steel Chicago Screws 3/8" – for wrist hinge/joint and 1/2'' for the fingers. You need two 3/8'' for the wrist hinge/joint and five 1/2 '' for the fingers. For the wrist Chicago screws, include a plastic washer (see STL files) on each 3/8'' Chicago screw post. The stainless Steel Chicago screws for the finger can be replaced by Aluminum Chicago Screws.
- Genuine Velcro 30' Length x 2" Width. It is sold by the roll, but you need about 24'' inches. (http://www.amazon.com/dp/B006AWFGJ2/ref=pe_385040_30332200_pe_309540_26725410_item)
- Shade Cord (Or Lift Cord) 0.9 mm (http://www.amazon.com/Roll-Yards-Shade-Cord-Lift/dp/B006DDHVM8). It is sold by a roll of 100 yards, but you need about 2 yards.
- 2mm Black Elastic Bead Cord (http://shop.hobbylobby.com/products/2mm-black-elastic-bead-cord-183418/). It is sold by a roll of 5 yards, but you need only 1 yard.
- Firm Foam Padding. Sold by a roll of 25' feet, but you only need 1 foot. (http://www.pattersonmedical.com/app.aspx?cmd=getProductDetail&key=070_921018416)
- Sleeve arm protector (http://www.expressmedicalsupplies.com/derma-sciences-glensleeve-arm-protectors-p-10193.html)

If you prefer to obtain all of the necessary assembly materials in one place, 3D Universe offers kits containing all of the assembly materials needed for a single Cyborg Beast.

http://shop3duniverse.com/collections/3d-printable-kits/products/e-nable-hand-assembly-materials-kit-cyborg-beast-edition

Assembly Instructions

Assembly tutorial:

https://www.youtube.com/watch?v=2KCOYrcSKd4

Tips for installing the tendon lines:

https://www.youtube.com/watch?v=HyM5frvLgjs

Note: *You may need to drill the holes a little bit to increase their size so the Chicago screw fit properly. Due to scaling the size of the holes get distorted.*

1. Place -1/2" Chicago screws in finger (Figure 1) and 3'' to 3 1/4"(or larger) Chicago screw in knuckle joints (Figure 2). It is recommended to place Teflon tape (http://www.amazon.com/Teflon-Tape-1-2-in/dp/B00004TZP8) on the treads to firm the screws so they don't come loose. Ensure fingers move smoothly. If not, clean holes and remove plastic residues from the support plastic structure.

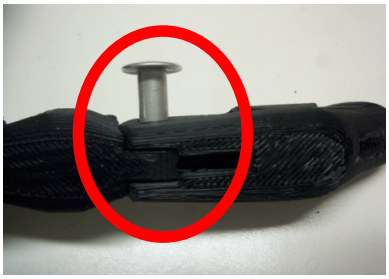


Figure 1. Finger Chicago Screw (1/2'')

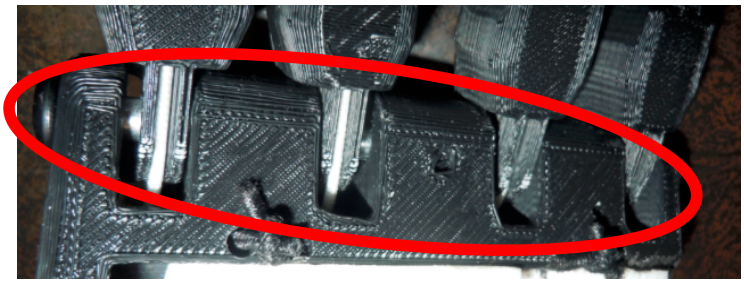


Figure 2. Knuckle Chicago Screw (3'' to 3 1/4"or larger)

2. Cut and apply adhesive firm foam padding on the sides of the forearm gauntlet (Figure 3 and 4), back of the knuckle area (front part of the hand, see Figure 5), and any other area that may be in contact with the skin.

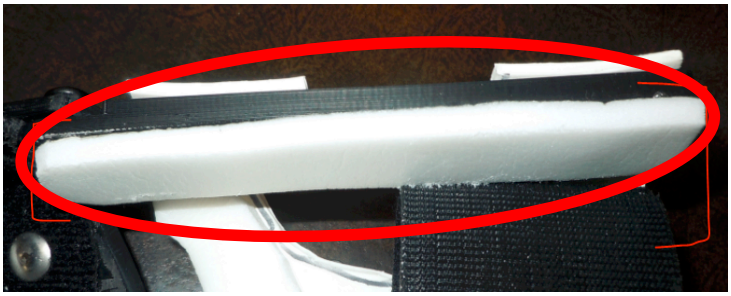


Figure 3. Gauntlet with firm foam padding (one side)

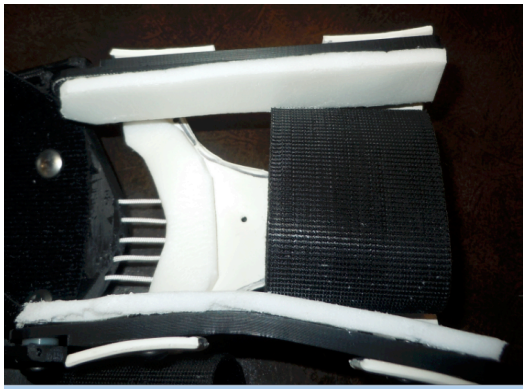


Figure 4. Gauntlet with firm foam padding (both sides and on top)

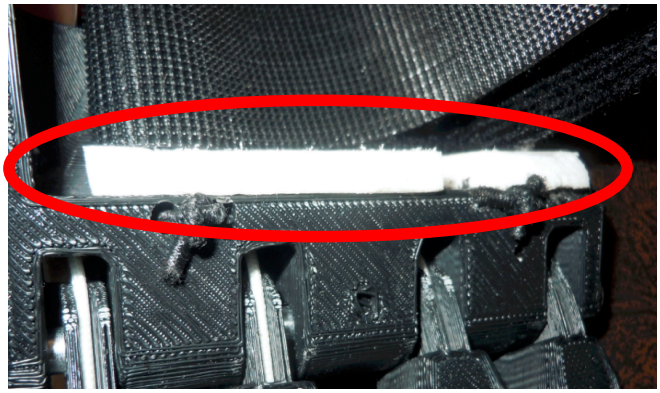


Figure 5. Knuckle with firm foam padding

3. Cut 2 pieces of Velcro, about 8'' inches long (smaller or larger depending on the forearm and hand circumference of the individual, see Figure 6). Cut another two Velcro pieces of about 6'' and 2'' inches long.
4. Cut 3 holes to fit the3/16" (or 1/4'') Chicago screws posts on the two pieces of Velcro that are 8'' inches long (Figure 6 and 7). Make sure that one piece is aligned with the holes in the hand and the other is aligned with the holes in the forearm gauntlet. Place the Chicago screws posts **to ensure that the soft side of the Velcro will be in contact with the skin** (Figure 8). Place these two pieces on the hand and forearm gauntlet.

Figure 6. Velcro 8'' long piece (hand gauntlet)

Figure 7. Velcro 8'' long piece (forearm gauntlet)

Figure 8. Velcro 8'' long piece (soft side)

5. Use the 6'' and 2'' inches long pieces of Velcro to cover the smooth side of the Chicago screw posts on the hand and forearm gauntlet, respectively (Figure 9).

Figure 9. Velcro 8'' long piece (hand gauntlet) and 6'' long (cover for the binding posts).

6. On the wrist hinge/joint place the 3/8" Chicago screw posts and add a plastic washer (included with the STL files) between the hand and forearm gauntlet hinges.

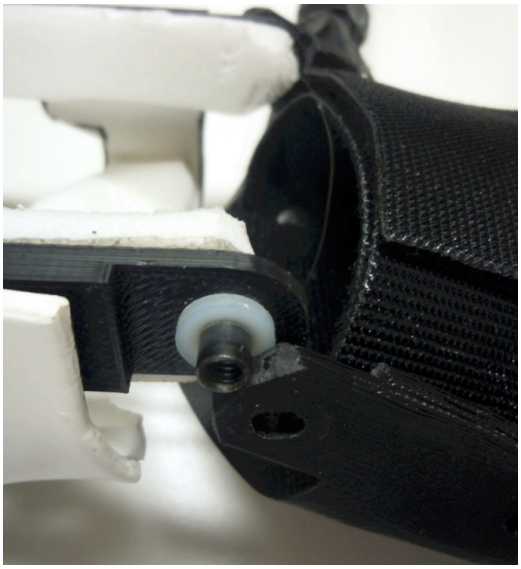


Figure 10. wrist hinge/joint plastic washer placement

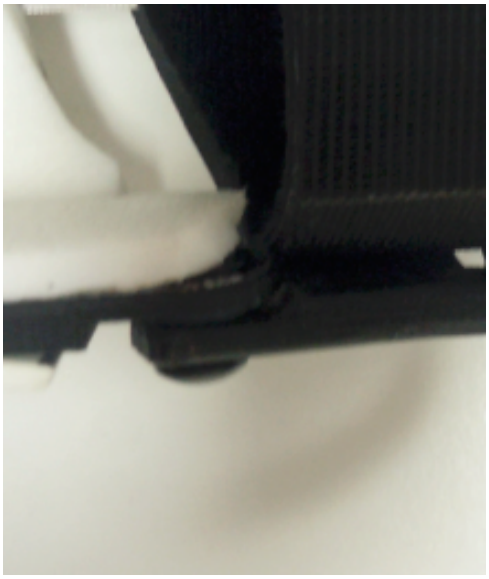


Figure 11. wrist hinge/joint completed

Velcro Installation for the New Cyborg Beast Gauntlet

The latest design of the Cyborg Beast gauntlet incorporates slots for easy installation of the Velcro straps.

1. Cut a 12'' piece of Velcro and 2 other small pieces (2 to 3'').
2. Tread the long piece of Velcro between the holes (figure 12)
3. Place the two small pieces of Velcro (2 to 3'') over the plastic inside of the gauntlet (figure 13).
4. Add padding as needed in those areas where the skin may be in contact with the plastic (figure 14).

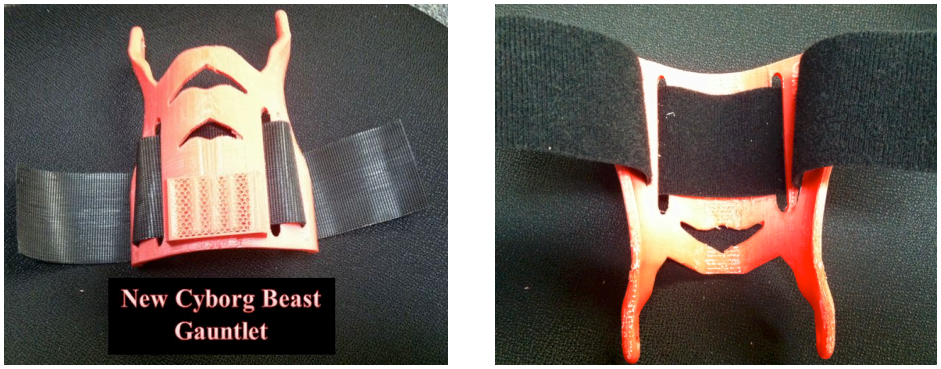


Figure 12. New Cyborg Beast Gauntlet

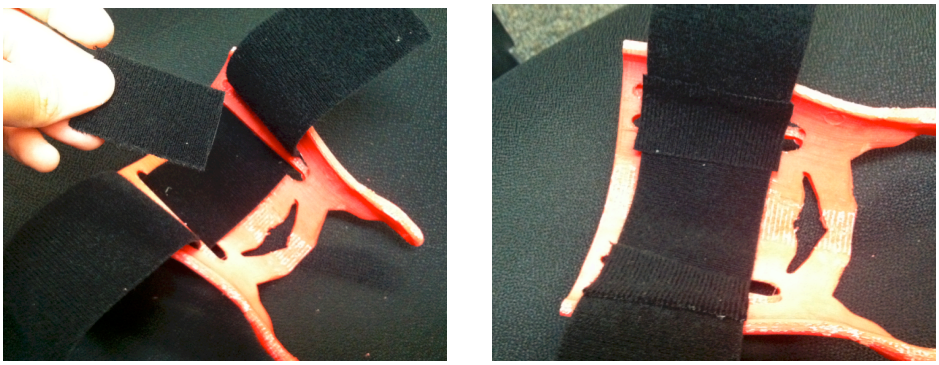


Figure 13. New Cyborg Beast Gauntlet

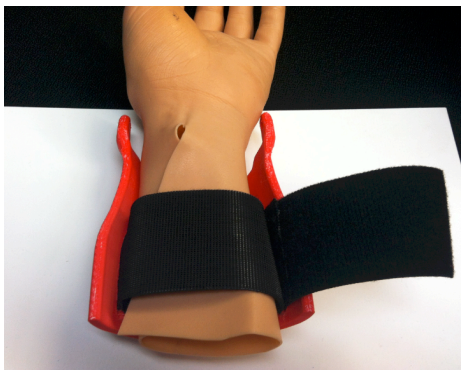


Figure 14. New Cyborg Beast Gauntlet

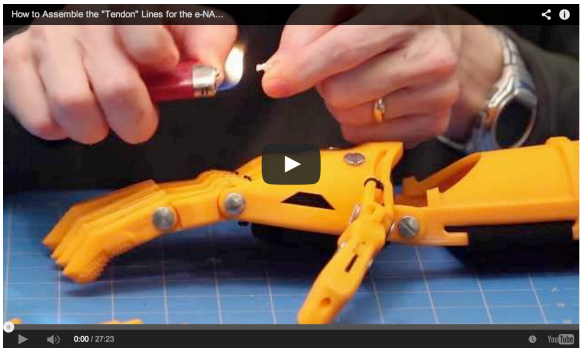
Installing the Elastic and Strings

For these steps refer to the Snap Together Robohand instruction manuals from page 41 to 61

Click the link below, then click download this thing and the manual is the last file ("Snap_Togeather_Robohand_Instructions").

http://www.thingiverse.com/thing:92937

Tips for installing the elastic and strings:



https://www.youtube.com/watch?v=HyM5frvLgjs

Owen's Tensioner System

Ivan Owen took the time to make a quick video to explain the assembly and function of the tensioner system included in the forearm gauntlet of the Cyborg Beast:

http://www.youtube.com/watch?v=vimeVMZjS6E&feature=youtu.be

General Recommendations for e-NABLE Prosthetic Devices

Statement

Based on preliminary testing and observations on the functionality and capabilities of the Cyborg Beast experimental 3D printed prosthetic device, it is felt that they are currently not safe for operation of heavy machinery, tools, equipment, and vehicles due to low grip strength development. The Cyborg Beast design has been shown to provide some functionality for gross grasp activities of light and pliable objects, but it is in no way a substitute alternative for a fully functioning hand. In addition, we don't recommend the use of our experimental 3D printed prosthetic device for small children (i.e., under 3 years of age) due to greater fall rate and the need of sensory input through oral stimulation. Furthermore, it is unknown if the Cyborg Beast experimental 3D printed prosthetic device is able to sustain a small child's bite without breaking. Please review and consider the following recommendations and precautions regarding the Cyborg Beast experimental 3D printed prosthetic device.

Physical Safety

Work with your doctor or medical professional for appropriate use and wearing schedule of your experimental 3D printed prosthetic device.

These devices are made with low temperature plastic and should not be exposed to temperatures over 120° F (approximately 50° C). A 3D printed prosthetic device left in a car on a hot day may be damaged.

With any prosthetic device, there is a possibility to develop pressure sores. If redness develops after wearing for the first 15-20 minutes, please contact provider of the device, to reevaluate fit. If redness persists, please contact your healthcare provider.

Monitor your device for wear and tear and contact your provider for assistance with replacing worn or broken parts.

Users should assume that the device could break at any moment, even while using it for tasks that have worked in the past, because the rate at which the plastic parts fatigue and need to be replaced is unknown.

Do not use the device to lift boiling water off the stove (e.g. cooking pasta) or to lift dishes of very hot food out of a microwave oven or out of a hot oven or any other situation in which a failure of the experimental device could cause injury indirectly if the hot material is dropped or spilled.

Health Safety

Allow the mechanical hand breathing room as excessive sweat and other components may cause poor hygiene and lead to skin problems.

The use of a prosthetic sock is recommended for individuals with sensitive skin.

Make sure you have no allergic reactions to the material used to print the mechanical hand or any other component.

Make sure the mechanical hand is comfortable.

Ensure the mechanical hand is functioning for the correct purpose.

Start using the hand in a progressive manner. If the muscles of your wrist joint are tired, it would be a good idea to take a break and continue using the mechanical hand the next day.

Child Safety

Children need to be supervised at all times while using these mechanical hands.

Young children cannot be trusted to watch out for the Health Safety items listed above. It is the responsibility of the caretaker to check for any problems with the child using an experimental 3D printed prosthetic device.

Let the child use/play with the device in a very conservative, progressive schedule: just 5-10 minutes at a time, or even less. If the child likes the device and is eager to use it, let them work up to using it for longer periods of time gradually. Talk with a pediatrician or other medical professional about how much use is safe for the child, and what other problems to watch out for.

If your child feels pain on the wrist or elbow joint, please stop using the mechanical hand. This may be a sign of an overuse injury.

If any component of the mechanical hand breaks, please stop using it.

Ensure that the hardware and other moving parts are not loose, especially for children young enough to be at risk of choking on foreign objects.

The use of the experimental 3D printed prosthetic device should be coordinated with the child's teacher and health care providers.

This experimental 3D printed prosthetic device is not made for weight-bearing or supporting body weight, so outdoor or rough play with the device should be closely monitored.

Children who are not walking or are unsteady on their feet may not be appropriate for this device as falling on the 3D printed prosthetic device may result in further injury.

Cleaning instructions

The 3D printed prosthetic device can be surface cleaned with warm water and a mild detergent. If an odor develops on the device, cleaning with shaving cream may help to dissipate the odor. If Velcro straps become worn or ineffective, please contact the provider of your prosthetic hand for replacement.